Interoperability Maturity Roadmap Methodology, V1.3

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Summary

This Interoperability Roadmap Methodology document supports the U.S. Department of Energy (DOE) Grid Modernization Laboratory Consortium (GMLC) Interoperability project's efforts to advance interoperability as an essential component of the successful and more seamless integration of intelligent, communicating technologies into the electric power system. The proposed methodology supports the strategic approach to advancing interoperability described by the GMLC Interoperability project in *Interoperability Strategic Vision: Enabling an Interactive Grid.*[1,2] That document proposes engaging an ecosystem of organizations (along with associated products and services) interested in integrating smart technology with the electric power system to develop an interoperability roadmap using a methodical approach. This roadmap methodology is to be applied to stakeholders belonging to technology ecosystems (e.g., technology deployments of electric vehicles, photovoltaic inverters, or automated buildings) using tools that measure the state of interoperability today and identify the gaps and challenges associated with improving interoperability to achieve the objectives of simplifying the integration process.

The roadmap methodology considers the GridWise Interoperability Context-Setting Framework's[3] interoperability categories. Within and across technology ecosystems, there are different approaches to advancing interoperability and these different approaches may change in the future. The interoperability roadmap methodology recognizes that the approach to advancing interoperability must be flexible and not necessarily universally uniform within every ecosystem. The interfaces tend to already be at different levels of maturity of interoperability. Improving interoperability is not a case of starting with a blank sheet of paper. Devices, systems, and processes already exist, and improvements mean providing reasonable transition paths from previous integration processes and standards to the new features. The resulting roadmap should clearly portray the stages of evolution anticipated in moving toward a vision that addresses important integration issues.

To help accomplish the process of developing a roadmap, the methodology uses the Interoperability Maturity Model[4] (IMM) as a tool to articulate a baseline level of interoperability and to identify the gaps and priority aspects to consider for evolving toward higher levels of interoperability maturity. The IMM was created in parallel with the roadmap methodology because of their close relationship. The ultimate goal of a roadmap effort is to improve the interoperability maturity level to levels that meet ecosystem objectives while being sensitive to the state of the art, the projected technology advances, and the cost/value of the effort.

The interoperability roadmap methodology provides a systematic approach to engaging members of a technology ecosystem to focus on the interfaces where integration takes place, consider the many areas that must be addressed to make integration simple and reliable, and form a prioritized set of actions that can improve the integration experience going forward.

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[1] U.S. Department of Energy, GMLC Interoperability Project, "Interoperability Strategic Vision: Enabling an Interactive Grid," April 2017, PNNL-26338. Accessed January 2020 at https://gridmod.labworks.org/sites/default/files/resources/InteropStrategicVision2017-04-11.pdf

[2] U.S. Department of Energy, GMLC Interoperability Project, "Interoperability Strategic Vision White Paper," March 2018, PNNL-27320. Accessed January 2020 at https://gmlc.doe.gov/sites/default/files/resources/InteropStrategicVisionPaper2018-03-29.pdf

[3] GWAC–GridWise® Architecture Council. 2008. Interoperability Context-Setting Framework v1.1. Accessed January 2020 at http://www.gridwiseac.org/pdfs/interopframework_v1_1.pdf

[4] U.S. Department of Energy, GMLC Interoperability Project, "Interoperability Maturity Model," January 2020, PNNL-29683. Accessed January 2020 at https://gmlc.doe.gov/projects/1.2.2

Acknowledgments

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The authors acknowledge the help and guidance received from the DOE managers, Marina Sofos and Christopher Irwin, in developing the plan for this document and encouraging outreach to relevant stakeholders. The final version of this guide was greatly influenced by the feedback received using the methodology for an interoperability roadmap exercise focused on Institute of Electrical and Electronics Engineers Std 2030.5[1]. The authors thank the members of the 2030.5 Ecosystem Steering Committee for their practical and valuable comments.

The model described in this document is an integral part of the interoperability roadmap methodology and the authors acknowledge the help and guidance received from members of that team, including Ron Melton and Keith Hardy.

Lastly, this work's value is determined by the participation of the broad grid modernization stakeholder community. Without stakeholder input and idea exchange at project review meetings and stakeholder engagement sessions, the ability of this material to influence the transformation of the electric system will vanish.

Acronyms and Abbreviations

DOE	U.S. Department of Energy
EPS	Electric Power System
GMLC	Grid Modernization Laboratory Consortium
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IMM	Interoperability Maturity Model
NIST	National Institute of Standards and Technology
RACI	responsible, authorized, consulted, informed

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1.0   Introduction

This document offers a structured approach to engage relevant groups of people interested in improving the integration of smart technology in electric power system application areas using standards, agreements, guidelines, and other supporting mechanisms that this community ultimately adopts and maintains.

Interoperable devices and systems connect and work together to provide a greater capability than the individual parts. The discipline of interoperability works to make the integration effort to achieve interoperation both simple and reliable. Doing so involves establishing a clear definition of the interface where the technology in question connects, and agreements about all the things that must be put in place to support the integration effort. It includes technical details, common terminology, compatible business processes and objectives, and trust that once connected, the technologies will work together because technology solution providers adhere to standards and rigorously test their product offerings. Achieving interoperability is a team effort involving a community of stakeholders (organizations interested in seeing that product and service offerings interoperate) who must work together to develop these agreements. This community is referred to as a technology ecosystem or simply ecosystem. The ecosystem is composed of buyers and operators of technology, technology suppliers, testers, standards developing organizations, market consortia, and those that oversee related commercial and regulatory policy.

Specific characteristics of interoperability can be stressed differently in different technology domains. As technology and business cases mature, attention paid to reducing integration costs takes on different levels of importance to fit different stakeholder needs. Interoperability is a multi-faceted, complex topic whose elements are nearly impossible to address all at once. Instead, the steps to advancing interoperability are broken down into a series of efforts to address the priority needs of the technology ecosystem members.

This interoperability roadmap methodology seeks to advance interoperability, not by creating a single roadmap for advancement, but by developing a methodology by which stakeholders can create roadmaps tailored to the technology domains and business scenarios they intend to address. The roadmap methodology described here is intended to be structured and repeatable. Consideration is given to the economic drivers for the interoperability effort and the level of effort required to advance interoperability.

The methodology is a facilitation mechanism for engaging members of a technology ecosystem in improving the state of interoperability as the technology and business landscape for deployment marches forward. In creating the interoperability roadmap methodology, the authors reviewed several technology roadmap processes and found one that fits well with the objectives of this effort. The International Energy Agency's (IEA's) *Energy Technology Roadmaps: A Guide to Development and Implementation*[1] offers a process for creating roadmaps that fits well with the needs for building consensus among the various parties interested in technology integration and enabling field deployments through standardized agreements. This approach was adapted to the specific needs of electric power system interoperability as described in the remainder of this document. Into this process the authors weaved the use of the Interoperability Maturity Model (IMM),[2] which provides the dimensions of interoperability for those using the roadmap methodology to to measure the state of maturity in each of these dimensions.

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[1] IEA–International Energy Agency. 2014. Energy Technology Roadmaps: A Guide to Development and Implementation. Accessed January 2020 at www.oecd.org/publications/energy-technology-roadmaps-a-guide-to-development-and-implementation-9789264086340-en.htm

[2] U.S. Department of Energy, GMLC Interoperability Project, "Interoperability Maturity Model," January 2020, PNNL-29683. Accessed January 2020 at https://gmlc.doe.gov/projects/1.2.2

1.1 Past Work on Interoperability

Significant work has already been done to define interoperability concepts and promote advancement for grid modernization efforts. The U.S. Department of Energy's (DOE's) GridWise Architecture Council and the National Institute of Standards and Technology (NIST) Smart Grid Interoperability Panel (now part of the Smart Electric Power Alliance) are two groups created by the U.S. government with industry support that have published guidance in this area. Additional information has been published by numerous other entities and stakeholders, including the Electric Power Research Institute, the International Energy Agency (IEA), and the Institute of Electrical and Electronics Engineers (IEEE). In the beginning phases of creating this document, the authors reviewed the following documents:

- *NIST Framework and Roadmap for Smart Grid Interoperability Standards*, Release 3.0, (NIST-SP-1108r3)

- *IEEE Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), End-Use Applications, and Loads* (IEEE 2030-2011)

- *GridWise Architecture Council Interoperability Context-Setting Framework*

- *GridWise Architecture Council Interoperability Maturity Model Beta Version*

- *IEA How2Guide for Roadmap Development & Implementation: Smart Grids in Distribution Networks*.

The authors reviewed these documents to identify lessons learned and gain insight into implementing interoperability in relevant domains. In large part, these documents provided the definition of terms and concepts as well as a framework for describing interoperability principles of system integration and overall system architecture. The authors consider these elements to be helpful, and even essential, to understanding and facilitating interoperability.

1.2 Tested Methodology for Developing Roadmaps

During the document review phase, the authors determined that the IEA's *Energy Technology Roadmaps: A Guide to Development and Implementation*[3] defines a highly structured, repeatable road-mapping process that is suitable for interoperability needs.

The IEA guide was designed to produce technology roadmaps associated with a specific technology—for instance, a roadmap for deploying advanced metering infrastructure across a large service area. Based on the methods described in the guide, the IEA has produced more than 20 technology roadmaps on topics as diverse as bioenergy for heat and power, cement, nuclear energy, and hydrogen and fuel cells. The IEA guide makes the point that it should be possible to map any supporting project or activity back to the roadmap to show how it contributes to the goals. It also specifies the following:

- how to structure stakeholder participation
- elements for a roadmap statement of purpose and scope
- how to develop a baseline
- how to plan a roadmap workshop
- resource constraints and critical inputs to consider

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[3] IEA–International Energy Agency. 2014. Energy Technology Roadmaps: A Guide to Development and Implementation. Accessed January 2020 at www.oecd.org/publications/energy-technology-roadmaps-a-guide-to-development-and-implementation-9789264086340-en.htm

- considerations for monitoring and tracking progress.

With its emphasis on consensus among stakeholders and built-in flexibility (through the tailoring section), the IEA guide is well-suited to providing a basis for a roadmap methodology for interoperability. A roadmap for interoperability is somewhat different, in that interoperability does not involve one specific technology. Rather, it is an enabling property intended to be incorporated into many specific technologies going forward. Therefore, the IEA process was adapted for the task at hand. The IEA guide itself was designed to be modified and contains a section on "Tailoring the Roadmap Process."

For this application, two new phases were added (Phases 1 and 6), one on each end of the IEA method as shown in Figure 1. Section 2.0 describes this expanded process.

Phase 1: Qualification & scoping → **Phase 2:** Planning and preparation **Phase 3:** Visioning **Phase 4:** Roadmap development **Phase 5:** Roadmap implementation and adjustment → **Phase 6:** Application to other domains

Figure 1. Interoperability-Specific Roadmap-Development Process

2.0 Interoperability Maturity Roadmap Methodology

The IEA guide describes a roadmap as…

> …a strategic plan that describes the steps an organisation needs to take to achieve stated outcomes and goals. It clearly outlines links among tasks and priorities for action in the near, medium and long term. An effective roadmap also includes metrics and milestones to allow regular tracking of progress towards the roadmap's ultimate goals.[1]

A key component of an effective road-mapping process is that it *maximizes stakeholder engagement* in creating the plan. The relationships established while building consensus among participants toward shared goals and results can help support roadmap development. Maximizing stakeholder engagement also increases the likelihood that the participants will implement the roadmap priorities.

The IEA guide provided important preliminary advice and recommendations. Highlights are listed below.

1. The roadmap effort leadership should evaluate the existing situation prior to roadmap development to determine whether a roadmap would be valuable or even necessary.

2. The roadmap process should be considered evolutionary in that as progress is made toward the roadmap priorities, more information becomes available, external factors change, and the roadmap must be revised.

3. A successful roadmap includes a clear statement of the desired outcome and states specific steps for reaching the goals.

4. Goals should be clear, concise, and designed so that if achieved, they will result in the desired outcome. If possible, goals should also be quantifiable so that clear, specific guidance can be provided and progress can be measured.

5. Milestones, as interim targets for achieving goals, should be keyed to specific dates.

6. Identifying gaps and barriers develops an understanding of the obstacles to achieving milestones and goals. Action items should be executed to eliminate the gaps and barriers.

7. Priorities and timelines identify the actions required to achieve goals within stated time frames. An important consideration is to evaluate the interrelationships among actions and roadmap participant or stakeholder roles and responsibilities.

The IEA guide notes that "If designed correctly, a successful roadmap should provide the ability to link any project or activity back through this logical structure to understand how the project or activity ultimately contributes to the achievement of the roadmap goals." The logical flow of the key elements described above is shown in Figure 2.
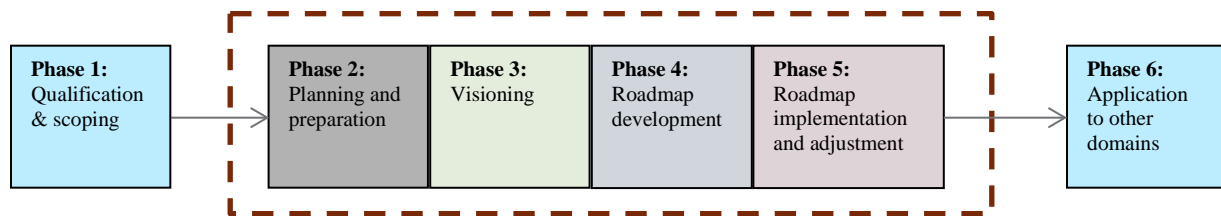
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[1] IEA–International Energy Agency. 2014. Energy Technology Roadmaps: A Guide to Development and Implementation. Accessed January 2020 at www.oecd.org/publications/energy-technology-roadmaps-a-guide-to-development-and-implementation-9789264086340-en.htm

Figure 2. Logic and Key Elements of a Successful Roadmap[2]

2.1 Roadmap-Development Process

The IEA guide advises that

> the process of developing a roadmap is as important as the final document itself: it represents consensus among the full range of stakeholders consulted in its development, who have considered potential barriers to deployment, sought early solutions and, in some cases, avoided anticipated issues altogether.

The IEA roadmap process is composed of two types of activities (i.e., expert judgment and consensus, and data and analysis) and four phases (i.e., planning and preparation, visioning, roadmap development, and roadmap implementation and revision). The success of a roadmap is based on early planning and foresight, establishing a commonly "owned" vision, gaining a full understanding of the national challenges and opportunities, acknowledging the importance of champions to advance the work, commitment to outcomes by both public and private stakeholders, and ongoing evaluation and progress reports. The development of a common vision can be informed by the desired integration vision espoused in the Interoperability Strategic Vision[3] document and this vision provides a converging force to separate technology roadmap efforts. Champions of the work need to be identified early to provide effective leadership and demonstrate their passion for achieving the desired outcomes.

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[2] IEA–International Energy Agency. 2014. Energy Technology Roadmaps: A Guide to Development and Implementation. Accessed January 2020 at www.oecd.org/publications/energy-technology-roadmaps-a-guide-to-development-and-implementation-9789264086340-en.htm

[3] U.S. Department of Energy, GMLC Interoperability Project, "Interoperability Strategic Vision White Paper," March 2018, PNNL-27320. Accessed January 2020 at https://gmlc.doe.gov/sites/default/files/resources/InteropStrategicVisionPaper2018-03-29.pdf

The roadmap-development process (Figure 3), as modified from the IEA road mapping process, is designed to assure that the roadmap identifies shared goals and establishes specific and achievable actions toward realizing a common vision.

	Qualification and scoping	Planning and preparation	Visioning	Roadmap development		Implementation, monitoring and revision	Assessment for application to other domains
ROADMAP							
Expert judgement and consensus	Interoperability champion initiates roadmap development process and selects key steering committee members	Establish steering committee. Determine scope and boundaries. Select stakeholders and experts.	Conduct senior level vision workshop to identify long-term goals and objective	Conduct expert workshop(s) to identify barriers and prioritize needed technologies, policies and timelines. Full IMM assessment.	Develop roadmap document Conduct review and consultation cycles with key stakeholders.	Conduct expert workshop(s) to reassess priorities and timelines as progress and new trends emerge. Update roadmap as needed.	Steering committee conducts preliminary assessment for applying to other domains. Review with champion. Select stakeholders.
	Phase 1	**Phase 2**	**Phase 3**	**Phase 4**		**Phase 5**	**Phase 6**
Data and analytics	Executive overviews of roadmap process, executive vision, IMM tools and application, expected benefits and resource requirements.	Conduct baseline research and preliminary IMM assessments for key interfaces and technologies.	Analyze future scenarios for key conceptual and technology domains to inform long-term interoperability goal-setting.	Develop full IMM baseline interoperability maturity and desired targets.	Refine and launch roadmap.	Track changes in key conceptual and technology domains as roadmap is implemented. Monitor progress in implementing roadmap.	Reassess domain requirements. Review IMM toolkit and adjust as needed. Revise expected benefits and resource requirements.
	1 to 2 months	1 to 2 months	1 to 2 months	2 to 6 months	2 to 8 months	Recurring 1 to 5 years	1 to 3 months

8 to 23 months total – not including recurring updates

Figure 3. Interoperability Roadmap-Development Process

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2.1.1   Expert Judgment and Consensus

Participant buy-in is essential and expert judgment input and consensus building activities are important steps in developing buy-in during the road-mapping process. The primary method of conducting these activities is through workshops that bring together a cross section of experts to develop roadmap goals and milestones, identify gaps, determine priorities, and assign tasks. The IMM tool is important to introduce in this early stage. Expert judgment is often necessary to make choices when data and analysis activities identify several possible scenarios or options. Roadmap workshops will seek to convene diverse technical expertise to assure a broad set of viewpoints. A critical first step is to develop a good definition of the technology ecosystem and its stakeholders for participation in a road-mapping effort. Doing so will identify the business scenarios and the interfaces that will be evaluated for interoperability maturity. The activities will be structured to develop an overall vision and strategy for interoperability and will seek to accomplish the following goals:

- Identify the appropriate parties (stakeholders) who need to be a part of the roadmapping process.
- Define the target scenarios and related technology domains.
- Build consensus on shared goals, milestones, and time frames.
- Evaluate and verify assumptions.
- Identify critical market, policy, social, technical, institutional, or regulatory factors.
- Develop current baseline conditions and interoperability maturity levels.
- Identify key barriers or obstacles.
- Determine alternatives to overcome barriers.
- Develop implementation strategies.
- Prioritize future actions.
- Decide if the road-mapping process can be streamlined.

2.1.2   Data and Analysis

If needed, expert judgment activities may leverage additional, more detailed data and analysis to support the establishment of current baseline conditions. Definition of the baseline interoperability maturity level is a prerequisite to setting milestone and performance targets and defining strategies to achieve the roadmap goals. The data and analysis activities are tailored to meet the needs of the expert judgment activities and are dependent on the amount and quality of available data and the time and resources available to the road-mapping team.

Key insights and data are derived from the results of the using the IMM tool. The IMM consists of a set of questions to identify the level of maturity for each criterion. The answers, or output, of the IMM tool show the baseline interoperability capability maturity level. This baseline is compared to the target levels for each criterion and a set of prioritized actions is developed to adjust the baseline to meet target levels where appropriate.

2.2   Phase 1: Roadmap Qualification and Scoping

This phase is the executive action phase. In this phase, the primary champion has determined a potential business need to make interoperability improvements in one or several areas. The champion convenes the core of the steering team. The steering team is responsible for determining if a business case exists for the interoperability efforts to be undertaken. Hence, the initial job of the steering committee is to provide business justification so the executive champion can cement the business case for these efforts with other executive leadership. If this step is successful, the steering team adds members as necessary to see that the appropriate parties are participating in the roadmapping process and proceeds to Phase 2.
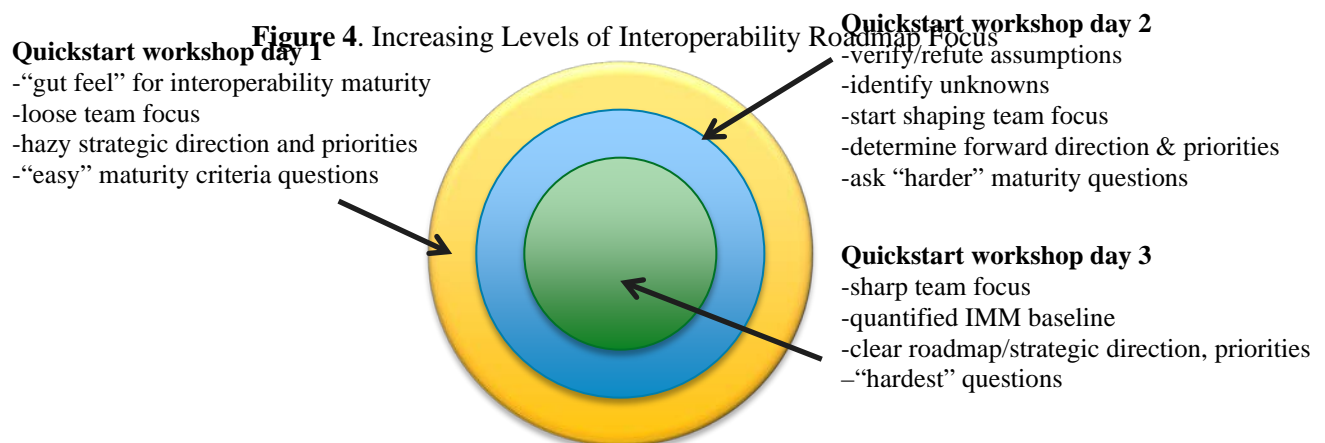
2.2.1　Steering Team Business Case Evaluation

Determination of a business case for the interoperability efforts is an important first step. The main deliverable from this evaluation will be a clear understanding and documentation of the value an interoperability effort would bring to participants. Supporting materials will include the following:

1. With the relevant domain in mind, discuss interoperability improvement/maturity concepts, goals, gaps, and desired maturity. Deliverable: Interoperability Readiness Checklist (see Appendix B for an example.)

2. Review the Interoperability Readiness Checklist and develop a high-level understanding of actions needed to reach desired maturity. Deliverable: summary document of actions needed –Path Forward document.

3. Discuss and develop a recommended prioritized action plan, including expansion of team, next steps, understanding of time, budgets, resources. Deliverables are

   - a prioritized Action Plan
   - Preliminary Interoperability Improvement Roadmap Scope.

In the early stages of investigating the current state and future needs for interoperability, the executive champion may choose to host an interoperability "quickstart" workshop to provide a short introduction to the steering committee about how individual organizations can implement interoperability improvements. This introduction is not intended to replace a full maturity baseline and roadmap-development effort. Rather, this is intended to provide the steering team with sufficient background about the process and explanation of interoperability improvement benefits to support a full maturity baseline and roadmapping exercise.

This quickstart workshop would take place over a one-week period and would introduce tools for assessing and improving interoperability. The sections below describe the mechanics of conducting the workshop and describe the main phases of evolving a preliminary interoperability baseline and a tentative roadmap for improvements during the workshop. The workshop is intended to provide a clear justification to the steering team for further roadmapping steps. During the workshop, the steering team gains focus and direction as members discuss interoperability maturity concepts and answer maturity criteria questions.

Figure 4. Increasing Levels of Interoperability Roadmap Focus

Quickstart workshop day 1
-"gut feel" for interoperability maturity
-loose team focus
-hazy strategic direction and priorities
-"easy" maturity criteria questions

Quickstart workshop day 2
-verify/refute assumptions
-identify unknowns
-start shaping team focus
-determine forward direction & priorities
-ask "harder" maturity questions

Quickstart workshop day 3
-sharp team focus
-quantified IMM baseline
-clear roadmap/strategic direction, priorities
–"hardest" questions

2.2.2 Interoperability Quickstart Workshop

A suggested work plan for the quickstart workshop is presented below.[1]

Preplanning

- Preliminary exchanges with interoperability champion
- Selection of key "steering team" members to manage workshop details and logistics
- Interoperability Readiness Checklist filled out by steering team (see Appendix B)
- Preliminary discussions with key steering team members:
  – Review of "interoperability readiness checklist"
  – Agreement on workshop approach and goals
  – Confirmation of attendance of key participants.

Day 1: Kick-Off Meeting

1. Interoperability Facilitation Team
   a. High-level overview of project, and sponsor's perspective and goals
   b. Discussion of terminology (interoperability, integration, etc.)
2. Organization Team
   a. High-level overview of organization, goals, structure, and previous experience with interoperability
3. Declaration of workshop approach and goals
4. Open discussion of interoperability challenges and opportunities

Day 2: (Example) Roadmap Phase 1

1. Overviews of roadmap process
2. Review of Interoperability Maturity Model criteria and evaluation/scoring
3. **Exercise 1**: Select a category or categories to evaluate.
4. **Exercise 2**: Identify long-term goals and objectives.
5. **Exercise 3**: Select stakeholders and experts.
6. Discussion of expected benefits from interoperability improvements
7. Discussion of costs related to interoperability improvements

Day 3: (Example) Roadmap Phase 2

1. **Exercise 4**: Determine the scope and boundaries.
2. **Exercise 5**: Perform a preliminary interoperability maturity baseline for one category.

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[1] In application of this concept, the GMLC team found it was challenging for stakeholders to commit to a week for a face-to-face workshop. In practice, the workshop content and goals will likely be modified depending on the time available. See Appendix A for additional details.

3. **Exercise 6**: Discuss relative priorities among criteria.

Day 4: Phase 3

1. Develop deliverables.

    a.   Interoperability team provides templates.

Day 5: Phase 3 (1/2 day)

1. Present findings.

Table 1. High-Level Work Plan for an Interoperability Quick Start Workshop

Interoperability Roadmapping Quick Start		Mon		Tue		Wed		Thu		Fri	
		am	pm	am	pm	am	pm	am	pm	am	pm
Preplanning	█	█	█								
Kick-off meeting		█	█								
Open discussion		█	█								
Interoperability Roadmap Quick Start – Session 1											
Review of roadmapping process				█	█						
Select steering team				█							
Review IMM				█							
Expected benefits				█							
Select a category					█						
Interoperability Roadmap Quick Start – Session 2											
Scope and boundaries				█	█						
Stakeholders and experts					█	█					
Perform IMM assessment					█	█	█	█			
Interoperability Roadmap Quick Start –Session 3											
Identify goals and objective								█	█		
Prepare deliverables									█	█	█
Present findings											█

At the end of the workshop, a roadmapping process report should be delivered to document the activities and provide a basis for further roadmapping efforts. The workshop report should include the following sections (note that a complementary PowerPoint slide presentation may be prepared with similar content and flow to highlight the findings at the conclusion of the workshop):

1. **About the Interoperability Effort**

    Provide a brief overview of organizational goals and importance of interoperability (half page).

2. **Benefits of Roadmapping**

    Provide a half page describing why roadmaps help.

3. **About the Roadmap Process**

Although the process will already have been explained during the week, provide a one-page description for people who did not attend or as a refresher for those who did.

4. **About the Interoperability Maturity Model Criteria**

Although the criteria will already have been explained during the week, provide a one-page description for people who did not attend or as a refresher for those who did.

5. **Process Followed**

Provide an overview of what was performed during the week, why it can only provide limited insights, and how a full roadmap process (specify duration) would lead to more (specified) benefits from a roadmapping process in general, and areas to focus on based on what has been learned so far.

6. **Description of the Ecosystem**

Describe the ecosystem using the stakeholders' language as much as possible. This is the ecosystem as they see it.

7. **Stakeholders Involved**

Describe (and diagram) the full scope of all ecosystem stakeholders needs and indicate who took part in the workshop exercise.

8. **Systems and Devices**

Describe the systems and devices included in the process. This may only be a subset, and if so, this needs to be made clear to provide proper context for the results.

9. **Standards in use and Planned**

List the relevant standards for further review and evaluation.

10. **Benefits Sought**

Summarize the first part of the process involving the steering team/stakeholders. Closely review the wording with those present during the exercise.

11. **Barriers to Eliminate**

Describe the barriers that the steering team/stakeholders have discussed. These may or may not represent actual barriers, but they give a strong indication of where perceived issues exist and areas where the stakeholders think that eliminating barriers will generate benefits.

12. **Concerns**

When describing concerns, reflect the input from the steering team/stakeholders. These may be concerns about the process, the lack of interoperability, or overcoming perceived barriers.

13. **Results of IMM Assessment**

Clearly show whether the target interoperability level was met or not. Indicate areas of strength and weakness. Note any uncertainty due to lack of clarity or lack of information. For a short effort like this, it may be that *no target level is set,* so this may be just an exercise to evaluate a part of the ecosystem for one interoperability category. There is a need to remain flexible.

14. **Preliminary Roadmap**

Describes the roadmap itself. What can be created realistically from such an abbreviated process needs careful thought and the team organizing the workshop will need a format for communicating the findings.

15. **Recommended Next Steps**

Link recommended next steps to the content of the roadmap.

The quickstart workshop report should inform the next steps in the overall roadmapping process. The steering team is intended to use this input to develop planning and preparation materials for the next stakeholder workshop. In addition, the executive champion is expected to review the workshop report and take action based on the recommended next steps.

2.3   Phase 2: Planning and Preparation

During the planning and preparation phase, the roadmapping team will complete the following tasks:

1. Determine the boundaries of the interoperability roadmapping effort.

2. Identify any existing tools, analysis, or other roadmaps that can be used to inform decisions.

3. Identify which technology domains the roadmap will consider.

4. Determine the time frame for the roadmapping effort.

5. Determine the current baseline interoperability maturity level of the domain under consideration using the IMM tool.

6. Identify how the roadmapping participants will implement and use the resulting roadmap and identify any external entities that will need to be engaged to achieve goals.

The following sections provide additional detail and guidance for Phase 2 tasks.

2.3.1   Assure Leadership Commitment

A top priority of the roadmap preparation and planning process will be to assure commitment from senior industry executives and/or policy officials. These individuals can champion the interoperability roadmapping effort by authorizing resources to complete the process, and they can also commit to implementing the findings. A draft statement of purpose, as well as a short, clear presentation of the initiative should be prepared to brief senior executives and policy makers to inform them and gain their approval, input, and commitment. Participation by senior executives in the roadmapping process is encouraged. It could be in the form of either opening remarks, direct participation in workshops, or the provision of staff experts to participate in the workshops and roadmapping process.

2.3.2   Appoint a Steering Committee

The road-mapping efforts are led by a steering committee whose members have the knowledge and authority to decide on goals, scope, and boundaries; direct work for obtaining additional data and analytics; and define the team responsible for implementing the roadmap. The number and type of steering team participants will be determined by reviewing the targeted domain, the list of stakeholders (to assure representation of key interests), and the plan for who will be involved in implementing the roadmap.

2.3.3   Develop a Statement of Purpose and Scope

The team will develop a short (i.e., two- to three-page) document that clearly describes the purpose of developing the roadmap; the scope, objectives, and expected outcome of the roadmap; the process for developing and implementing the roadmap; and the list of participants involved in developing and implementing the roadmap.

The statement of purpose and scope helps maintain focus throughout the roadmap-development process and helps to maintain commitment to the desired goals. The statement can also be used as a tool for educating new or external partners, participants, or other interested parties. The following sections should be included in the statement of purpose and scope:

- Purpose: Explain the reasons for developing the roadmap and the specific issues and challenges that will be addressed.

- Scope and Objectives: Explain the type and duration of projects covered by the roadmap.

- Process: Explain the methodology for roadmap development, along with the time to complete the roadmap. List and briefly describe the specific elements (e.g., vision and roadmap workshops; required data and analysis; periodic feedback and update workshops during implementation; and the process for monitoring, evaluation, and mid-course corrections).

- Participant: Describe the list of organizations, their types, as well as required expertise from participants and individuals expected to provide feedback during the roadmap process.

   The exercise of developing a responsible, authorized, consulted, informed (RACI) chart can be an effective means of determining the participant list. See Table 2 for an explanation of RACI charts.

Table 2. RACI Chart of Stakeholders, Categories, and Responsibilities

Category	Definition	Responsibility can include
Responsible	• This group, the steering committee, holds the authority to approve the final product. • To determine the size and composition of this group, consider the different stakeholders needed for roadmap implementation. • The steering committee should include senior representatives from the major stakeholder groups to assure best chances for implementation.	• Approve the roadmap goal, scope, and boundaries. • Approve the RACI chart. • Approve communications to the wider "informed" stakeholder community. • Assign the "authorized" members of the roadmap project team. • May contribute to direct analytical efforts.

Authorized	• This is the project team and will be the core team that performs the majority of work on the roadmap.
	• This team mirrors the composition of the steering committee at a working level.
	• A project leader is needed to coordinate activities and communications with other teams.
		• Project Leader
		  − Manage the project.
		  − Communicate with stakeholders.
		• Develop roadmap drafts.
		• Plan workshops.
		• Document gathered information.
		• Perform analysis.

Consulted	• Includes expert representatives from entities that have a key role in the development and implementation of the roadmap; this could include manufacturers, vendors, standards development organizations, trade groups, and other representatives that will be part of the workshops, analysis and roadmap implementation.	• Attend workshops. • Provide input. • Review roadmap drafts. • Commit to active participation in the process when appropriate.
Informed	• These are stakeholders not directly involved in the roadmap implementation but who may be affected by the roadmap; thus, these stakeholders have an interest in the roadmap and may be helpful during some workshops or during analysis.	• Be informed about roadmap recommendations and milestones. • Are not typically directly involved in the workshops or other activities

2.3.4   Conduct Baseline Research

The fourth step in the roadmapping effort begins by developing a baseline for the interoperability maturity level. The methods and tools for conducting the maturity assessment are detailed in the IMM document.[2] The baseline exercise will also identify the key factors affecting interoperability for the specific organization or project that will be implementing the roadmap. Key types of data that may affect the implementation could include the technology to be addressed by the roadmap, the market sectors to which the technology will be applied, and the internal or external policies (or governance) that could help or hinder the roadmap implementation. The aim of the baseline research is to develop accurate information about the status of maturity, costs, performance, technology readiness, manufacturers, vendors, market conditions and limitations, and a forecast or projection with information about the trends expected to affect interoperability in the target technology domain or project. Existing roadmaps may also provide information about relevant interoperability-related topics or technologies.

Figure 5 indicates the types of inputs obtained from the research work done during this phase of the methodology. These inputs reflect the groundwork needed before applying the IMM tool to see what is important and what cannot be touched or changed, and include the goals and drivers. Barriers help define the integration barriers or constraints.
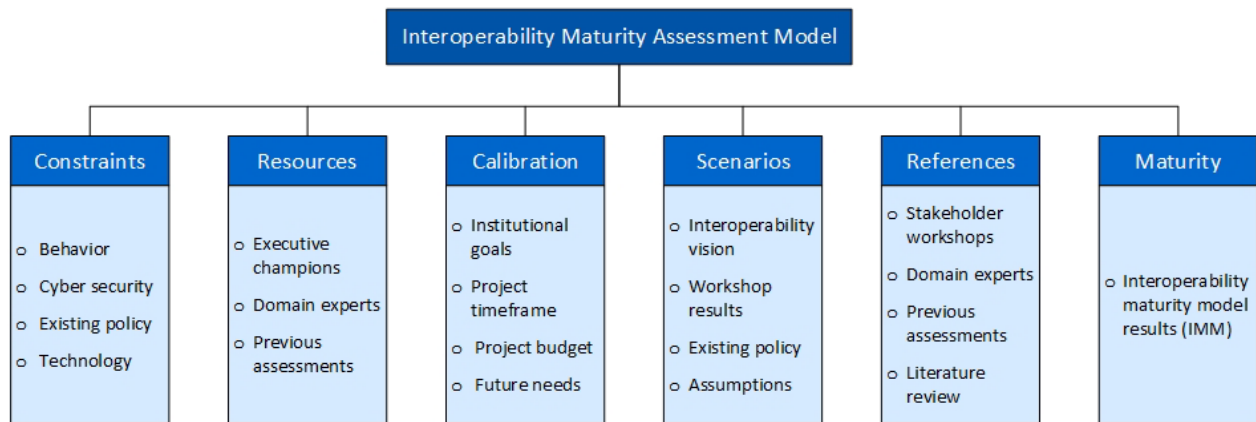

Figure 5. Interoperability Maturity Assessment Model Inputs

2.3.5   Select Stakeholders and Experts

Stakeholders, participants, and experts will be engaged as early as possible in the roadmapping process. An important first step will be to identify the roles and responsibilities of organizations and individuals. Decisions about the composition of the participants can be informed by reviewing the scope and objectives of the roadmap. Suitable participants will have appropriate levels of responsibility and expertise to provide appropriate guidance throughout the roadmap-development and implementation phases. Suitable individuals should also be willing to serve as roadmap "ambassadors" by educating others during the development and implementation phases. They may also be liaisons to related groups so that knowledge about the roadmap may spread and influence from the consensus process can have the greatest chance of widespread adoption.

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[2] U.S. Department of Energy, GMLC Interoperability Project, "Interoperability Maturity Model," January 2020, PNNL-29683. Accessed January 2020 at https://gmlc.doe.gov/projects/1.2.2

As a suggested guide for vision-setting workshops, 10 to 40 individuals will be selected to represent leadership in an industry group or technology domain. For expert workshops, from 50 to 200 participants may be recruited to provide input on challenges, needs, and suggested courses of action. A high-level view of the overall stakeholder involvement strategy is shown in Figure 6. As an aid to the stakeholder-selection process, the RACI chart shown in Table 2 can help organize the wide array of participants.
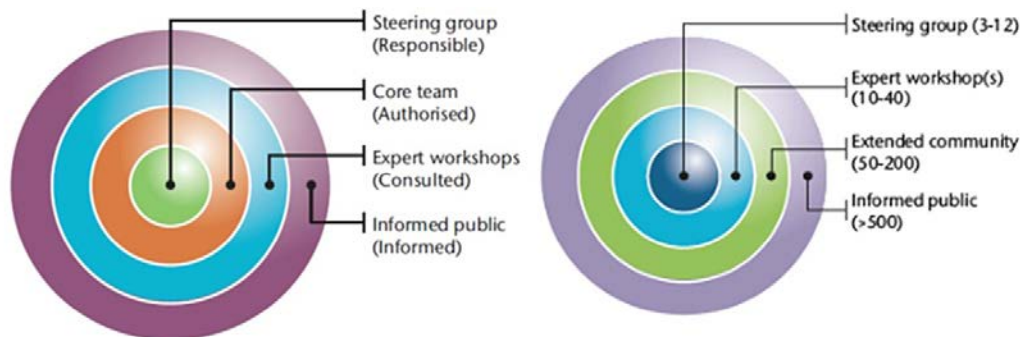
Figure 6. Roadmapping Stakeholder Involvement Strategy[3]

2.4 Phase 3: Visioning

Setting a vision is the process of defining the strategy to be used for implementing interoperability. This process includes consideration of current and future scenarios. Analysis of these scenarios can inform the participants about what future states are possible or likely to evolve. This, in turn, informs the long-term goals of the interoperability roadmap. The visionary aspect described in the Interoperability Strategic Vision document, including the desired integration stories and interoperability goals that transcend individual technology domains, can be reviewed at this stage to help bring convergence across grid integration efforts.

Visioning exercises can be included in a vision-setting workshop at which domain experts meet to discuss and collectively decide on the desired future interoperability maturity level. Participants can leverage results from data-analysis tasks to review and debate alternative scenarios or forecasts, if available. As part of the kickoff for such a workshop, the steering team may share current assumptions, methodologies, analysis, and results to assure all participants have a common understanding of the work and analysis done to date.

2.5 Phase 4: Roadmap Development

The roadmap-development phase follows from the visioning phase and relies on analysis and expert judgment to define the activities, priorities, and schedule to achieve the desired vision.

The IMM toolkit is required throughout the roadmap-development process to inform the roadmap-development stakeholders. During Phase 1, the interoperability champion requires an executive overview of the IMM and the roadmap process itself to successfully gain buy-in from the rest of executive leadership, and to kick off the roadmap process by selecting key steering committee members. The steering committee will require details to determine the composition of the experts needed and to determine workflow during the workshops conducted during Phase 3.

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[3] IEA 2014 includes the left drawing.

There are several suggested steps in this phase as described below.

2.5.1   Hold Roadmap Workshops

Roadmap workshops can be an effective way to solicit ideas from stakeholders and experts. It may be necessary to hold several workshops focused on specific issues or stakeholder groups (e.g., technology or finance/policy). Workshop planning should include defining the workshop process, identifying introductory presentations, creating a list of discussion topics and questions, and planning for the collection of participant input. Breakout sessions can be effectively used to obtain more detailed and targeted information. Prior to each workshop, the steering team should send a background document to participants that states the main questions to be answered at the workshop and provides a clear statement of the workshop's purpose, scope, process, and expected outcomes. A list of selected references is also recommended. Specific elements of a roadmap workshop background document can be found in the IEA roadmap guide.

2.5.2   Prepare the Draft Roadmap Document

The roadmap document is the means by which a narrative can be shared that describes and integrates the large amount of information and analysis into a compelling, rational sequence of activities that demonstrate how to achieve the desired maturity level. A variety of audiences should be kept in mind.

2.5.3   Conduct a Roadmap Review

A roadmap review process includes multiple cycles of review, with the first cycle being shared among all contributors to date. A revised draft is based on feedback from the expert community and moves from the initial set of contributors to a wider external audience of domain experts. The second review is presented as a near-final version. A third review may be necessary depending on feedback.

2.6   Phase 5: Roadmap Implementation and Adjustment

This phase is the culmination of many months of effort by many participants. As these steps are executed, close monitoring of progress is necessary, and adjustments may still be required.

2.6.1   Launch the Roadmap

The formal launch of the interoperability can be accomplished in numerous ways. When ready, a critical notification is given to the intended audience that the roadmap document has been finalized and is available for the next phase. This may be done during a roadmap launch kickoff meeting.

2.6.2   Begin Implementation

The roadmap document will describe a set of priorities, gaps that need to be filled, technology demonstrations needed, policy notes and/or regulatory changes, and financial and scheduling commitments needed to meet the roadmap goals. In many cases, the steering committee may evolve into the body that oversees roadmap implementation and tracking.

2.6.3   Monitor Progress and Adjust the Roadmap

The roadmap implementation body is responsible for tracking stakeholder efforts, gathering and disseminating results, and providing progress updates. If needed, the roadmap is re-evaluated and revised.

Workshops can be reconvened if expert judgment is required to revise goals, priorities, and schedule. In fact, regular workshops every three or five years to revisit key assumptions and progress may be advised.

2.6.4   Manage Expectations

Roadmapping should be approached as a "living process" that will require revisions past the roadmap's initial publication. Regular roadmap revision workshops will be necessary to modify the roadmap goals and priorities based on evolving technology and institutional requirements.

2.7   Phase 6: Methodology Assessment for Application to Other Domains

In this final phase, the project team will review lessons learned and make any needed adjustments to the roadmapping methodology itself. The team will then review what changes may be required to apply the roadmapping efforts to additional domains that have been identified earlier.

3.0 Conclusion

The interoperability roadmap methodology concentrates on the process of developing high-level, strategically oriented steps for advancing interoperability in a specific technology integration area. It is designed with a heavy emphasis on understanding the ecosystem of businesses and related stakeholders and the financial and policy drivers that make interoperability a worthwhile topic in which to invest their time and effort. Such motivation is necessary to garner participation in developing a roadmap, and more importantly, in taking ownership to make progress implementing the roadmap.

Linked closely with the roadmap methodology is the IMM tool. The IMM provides a structured way to explore the state of interoperability, which has many complex dimensions. It also serves to identify gaps and helps those participating in the roadmap process define their desired goals and prioritize the areas that need attention to achieve them. This enables the application of the roadmap methodology to concentrate on process-related concerns, while the IMM focuses on measuring the characteristics associated with achieving interoperability more simply and reliably.

"SIMPLY WRITING A ROADMAP IS NOT ENOUGH — THE TRUE MEASURE OF SUCCESS IS WHETHER OR NOT THE ROADMAP IS IMPLEMENTED AND ACHIEVES THE ORGANISATION'S DESIRED OUTCOME."

IEA *Energy Technology Roadmaps: A Guide to Development and Implementation*

Appendix A

Summary Results of the Application of the Roadmap Methodology

In 2018 and 2019, the authors applied the roadmap development methodology described in this report to an interoperability-oriented ecosystem concerned with the integration of responsive resources connecting to the electric power distribution system. Overall, the methodology was confirmed to be appropriate and adaptable to the concerns of this ecosystem. The timeline for the work is represented in Figure A.1. Specific observations are noted below.
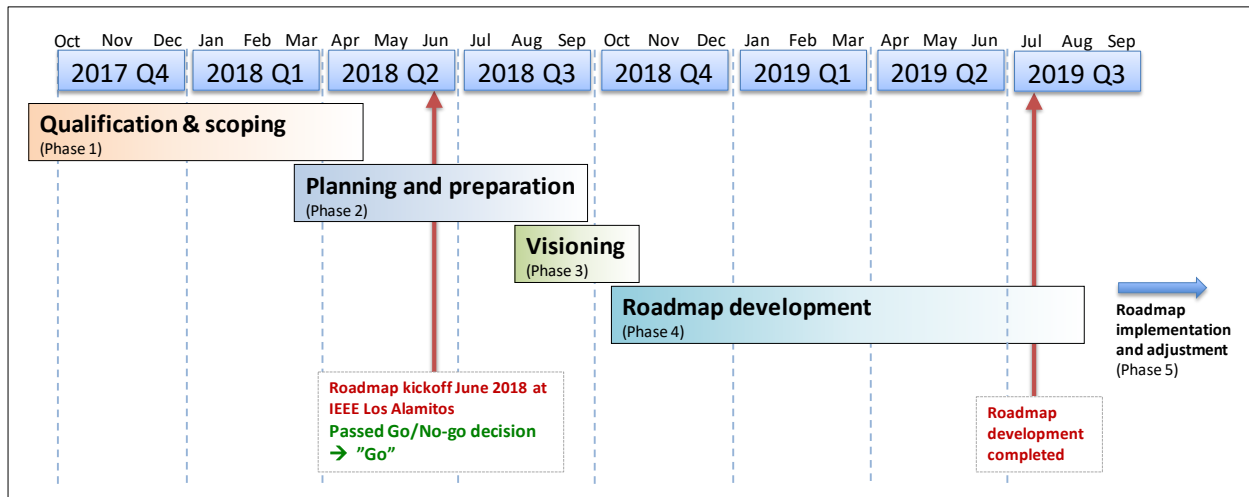
Figure A.1. Trial Run of IEEE Std 2030.5 Ecosystem Interoperability Maturity Roadmap Development

A.1 Qualification and Scoping

The Institute of Electrical and Electronics Engineers (IEEE) Std 2030.5 ecosystem was identified as a potential candidate for application of the roadmap methodology in mid-2017. The initial engagement with the "champions" occurred in the latter half of 2017. By early 2018, a core set of individuals (the leadership team) had coalesced and could be considered a proto-steering team. This team provided input toward creating a broader team that was more representative of the ecosystem. The process of recruiting additional individuals who eventually became members of the steering team took roughly four months. An interoperability readiness checklist was used to help lay the groundwork for scope and expectations (see Appendix B for an example).

A.2 Planning and Preparation

Two months were needed to develop and plan a kickoff meeting, which occurred in June 2018. Initially, the GMLC team proposed a week-long workshop in accordance with the roadmap methodology, but it became clear that such a time commitment was unrealistic. After discussion with the steering team, the kickoff workshop was scheduled to occur over a day and a-half.

During the workshop, the stakeholder group was introduced to the roadmap process and the Interoperability Maturity Model (IMM), and the group developed a preliminary interoperability baseline

using the IMM. Based on the initial results, the stakeholders confirmed there was an opportunity to improve interoperability for their ecosystem and there was business value to be gained in developing a roadmap, and therefore the effort was determined worth to proceed.

The team decided to hold one and a-half hour, biweekly meetings of the entire steering team. Additional leadership team conference calls were arranged in the interim weeks for high-level coordination and planning. During the June 2018 workshop, the team also developed a high-level timeline for roadmap development, starting with the visioning phase. The IEEE Standards Association offered an approach to formalize a 2030.5 Ecosystem Steering Committee (ESC) as part of their Industry Connections Activity forums for the purposes of developing an interoperability roadmap.

Over the next few months the team developed logistics for collaboration workspace, operating policies and procedures, working group structure, leadership positions, and a detailed schedule.

A.3 Visioning

The visioning phase occurred over a two-month period in starting in August 2018. During this phase, a document was developed that articulated the overall context of the effort, definitions of key terms, the scope and boundaries, the time horizon considered, and business drivers. Specific discussion topics led to articulation of a vision for the IEEE 2030.5 standard as a whole and identified related documents such as implementation profiles and interoperability test procedures. The vision document concludes with an illustrative scenario of distributed responsive resource integration that includes an implementation of IEEE Std 2030.5 with the future desired vision of interoperability maturity.

A.4 Maturity Assessment and Targets

After the visioning phase, the team began a detailed review and discussion of each maturity criterion in the IMM. This effort began in November 2018 and extended through May 2019. The GMLC team developed online polls to facilitate discussion of each maturity criterion. During the course of this exercise, the team discovered the need to revise and modify the wording of certain IMM criteria to better align with the nuances of standards rather than physical technology. The team found it necessary to discuss use cases to help focus discussion. The maturity assessment was codified in an interim document and spreadsheet, which eventually were merged with the roadmap document itself.

In June 2019, the ESC held their second face-to-face meeting to finalize the maturity assessment and to draft action plans for prioritizing and addressing gaps.

A.5 Interoperability Maturity Roadmap

After the face-to-face meeting, the facilitation team developed a draft roadmap document over the course of two months from July to August 2019. The document was reviewed, and comments were addressed in September and October. The leadership team chose to conduct a ballot to determine whether the document was finalized as intended. The ESC approved the ballot and the document incorporated final edits from IEEE and the group.

The roadmap document[1] has been released under a creative commons license to allow for open access to it, for update by the ESC and any succeeding organizations, and use by other ecosystem groups that may wish to develop their own interoperability roadmaps.

A.6 Conclusion

An important outcome of this effort is that, over the course of the roadmap development process, the ESC noted the need for a formal ecosystem alliance, which would be tasked with execution of the roadmap. As the roadmap document was nearing the final stages of development, elements of the roadmap, such as the prioritized action plan, were used to inform discussions about the structure and workplan of the future ecosystem alliance.

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[1] 2030.5 Ecosystem Steering Committee, "Interoperability Maturity Roadmap-IEEE Std 2030.5," October 2019. Accessible for free from IEEE-SA at
https://www.techstreet.com/ieee/standards/ieee-white-paper?product_id=2090693

Appendix B

Example Interoperability Readiness Checklist

This example exercise is intended to serve as a quick introduction to interoperability maturity measurement and roadmapping for distributed energy resource (DER) integration. The authors hope that the effort results in a heightened awareness of the goals and benefits that may be achieved through the process of determining a baseline interoperability maturity level and developing an interoperability improvement roadmap.

For the purposes of this exercise, interoperability means "the ability of two or more systems or components to exchange information and to use the information that has been exchanged."

The term DER is used to represent all energy-consuming and -producing resources at the edges of the system that have a responsive component for coordinated operations with the energy system. This includes flexible loads that can offer to change their consumption behavior (e.g., stop operating a motor or lights to shed load), distributed generation that can offer to change its power output or provide voltage support, and storage that can offer to act like either distributed generation or flexible load. The concept of DER also includes buildings and other facilities with systems that may manage a variety of equipment, some responsive (DER equipment) and some non-responsive. To harness the flexibility in operation of DER, their integration with the grid must be cost-effective and reliable. This is the mission of interoperability.

The following is a set of questions developed to inform the participants of key expectations and motivations regarding interoperability. The exercise is intended to be completed in under an hour. A key goal is to offer participants an opportunity to develop a shared understanding of the team's goals and preferences, what the team wants to achieve, and how to tailor the approach for subsequent discussions.

1. Why do you want to improve interoperability (what are the anticipated benefits, what problems do you want to solve)?

2. What problems has interoperability caused recently or in the past?

3. What concerns do you have about the impacts of the current levels of interoperability?

4. What are the perceived barriers to interoperability or improving interoperability today?

5. What key issues have driven interoperability cooperation with relevant stakeholders?

6. What devices/systems need to be interoperable to solve the problems identified?

7. What security issues does an interoperable ecosystem need to address?

8. Are there any existing/mandated interoperability requirements that you are concerned about meeting?

9. Are the current interface(s) focused on meeting minimum requirements, or looking ahead?

10. Do the stakeholders fully understand the complexities and nuances of the integration environment and the fundamental issues around information technology standards?

11. Would you describe the approach to interoperability as ad hoc or managed?

12. What additional data, policies, or processes would be helpful to meet your goals and why are they not collected/shared/used today?

13. What issues affect relevant material or information collection and sharing today?

14. What process do you use to evaluate the level of interoperability?

15. What process do you use to make needed improvements?